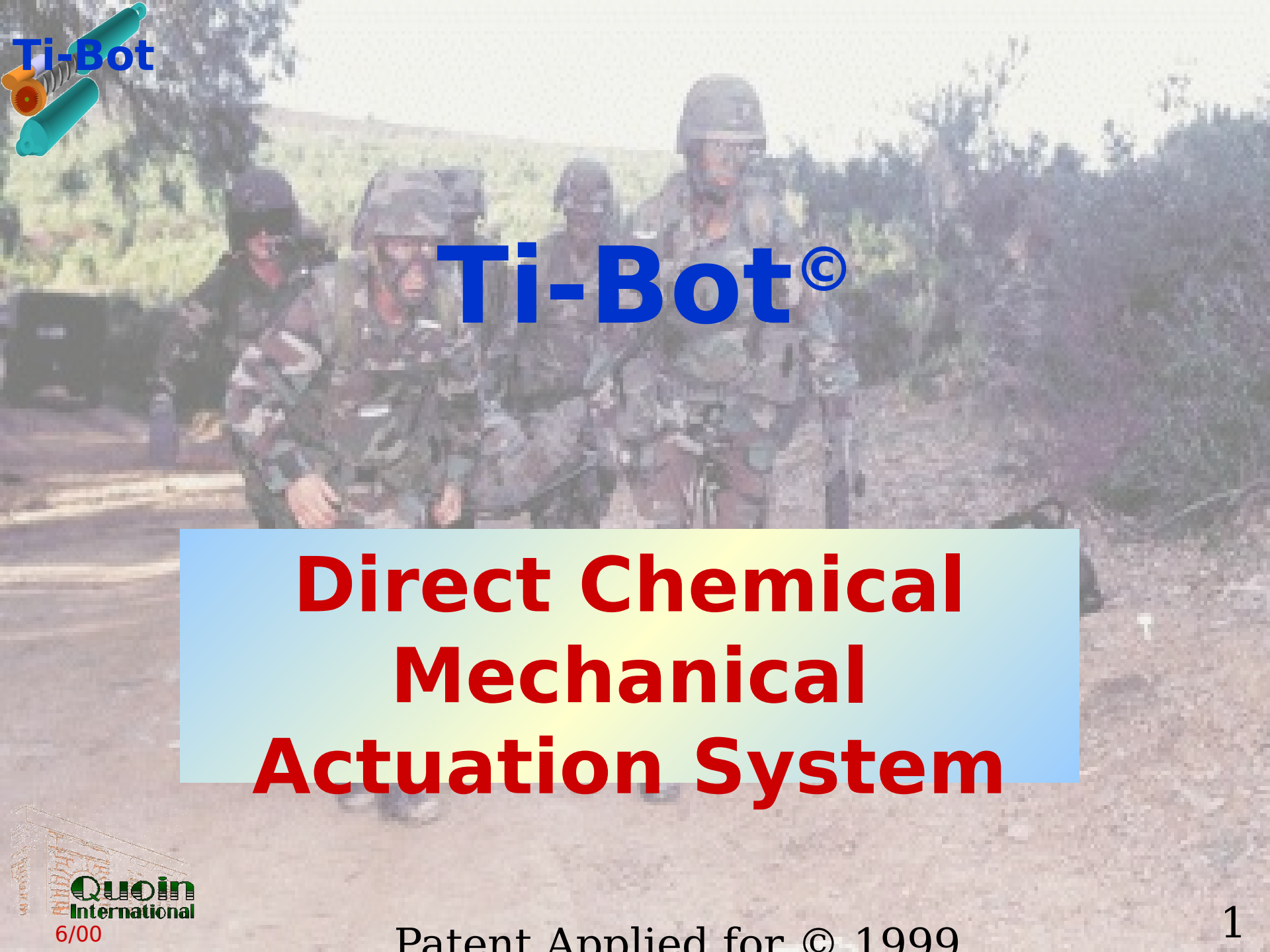

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Direct Chemical Mechanical Actuation System

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Program Goals

- Define feasibility of direct conversion of chemical to actuator output
- Phase I SBIR
  - Conduct trade studies of actuators and power supplies
  - Develop preliminary math model of system
  - Demonstrate feasibility of actuator
- Phase II SBIR
  - Refine trade studies
  - Simulate power supply and actuators
  - Design/build/test level I & II prototypes
  - Validate Simulation

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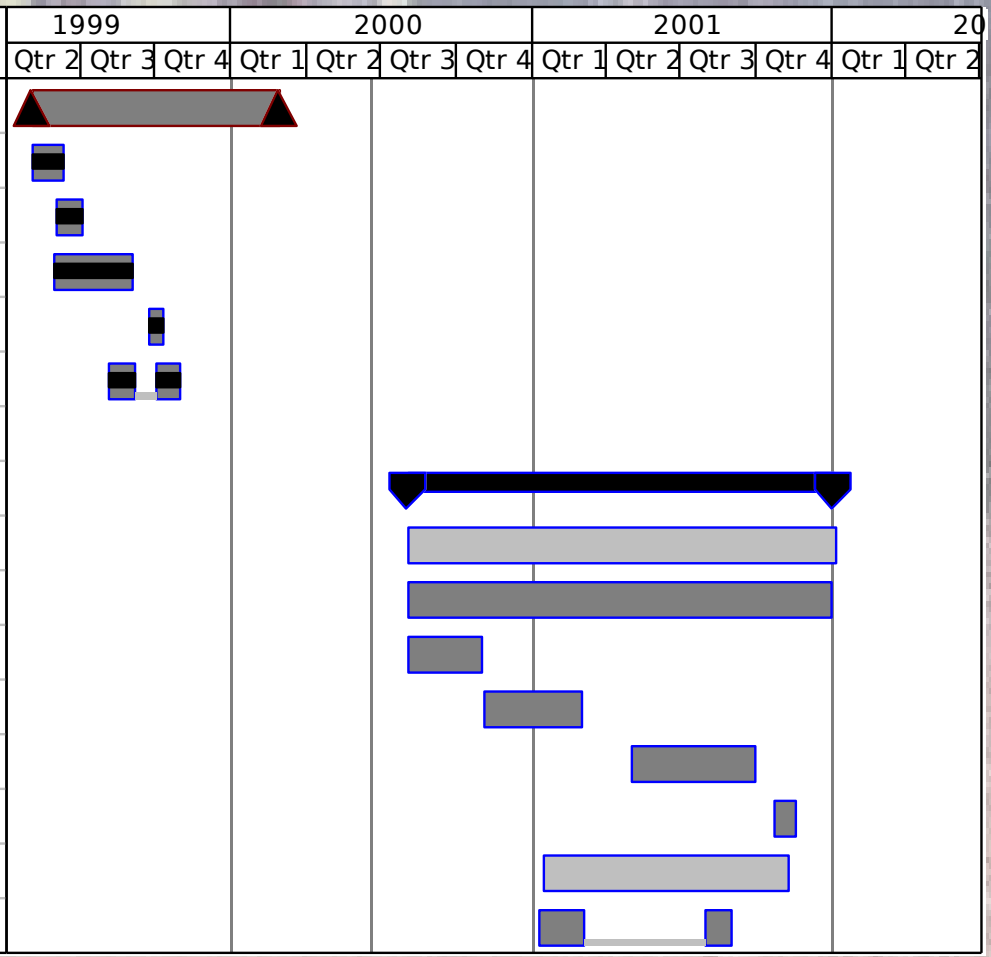
Program Plan

ID	Task Name
1	**Phase I SBIR**
2	Establish Design Requirements
3	Conduct Trade Studies
4	Design Selected Actuation Options
5	Conduct In-house Proof-of-Principal Testing
6	Conduct Commercialization Study
7	
8	**Phase II SBIR**
9	**Systems Engineering**
14	Dynamic Performance Analysis
15	Design Trade Studies
16	**Prototype I**
17	**Prototype II**
18	System Testing
19	Scaling Analysis
20	Conduct Commercialization Study



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Contractors and Roles

- Quoin International
- SCION Systems
- GMS
- Adams

- Prime Contractor
  - Requirements analysis
  - Mechanical design
  - System integration
- Servo electronics
  - Test equipment development
  - System software
- Precision Machining
- Solid Works (Ideas)

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Accomplishments 6/99-6/00

- Phase I contract award 11/99
- Completion of trade studies 2/00
  - Reversing Turbines
  - Free Piston Engine
- Technology Demonstration for reversing turbine actuator 5/00

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Requirements/Approach

- Use fuel/air as primary power source.
- Precision position and velocity control loops.
- 15-20 Hz bandwidth.
- High efficiency.

- Compressed air/fuel with catalyst bed reactor.
- Digital control with optical encoder. (0.005 inch resolution)
- 25 hz open loop.
- Peak 15% now up to 25% future.

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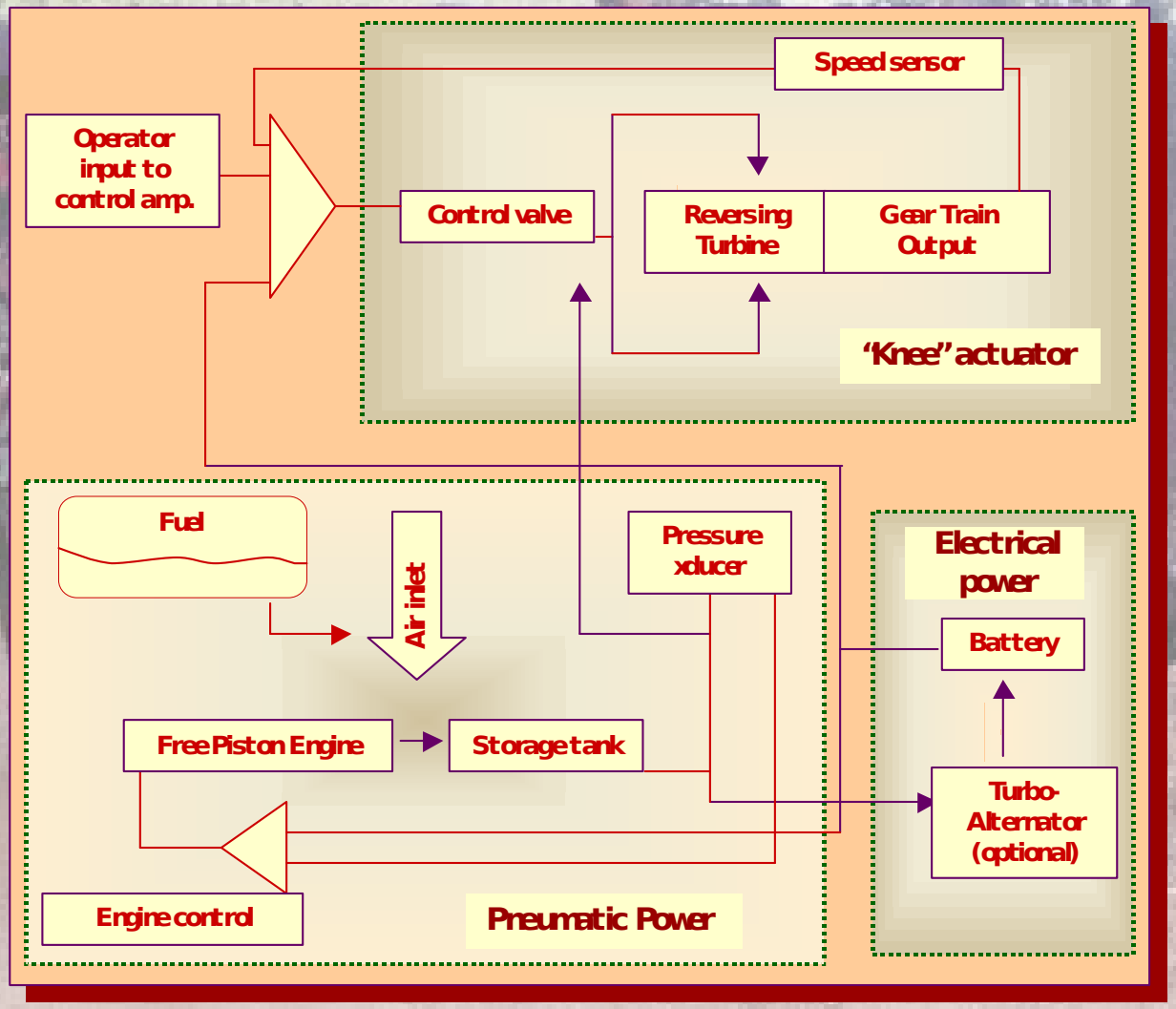
System Schematic



System Schematic describes the complete power and control system

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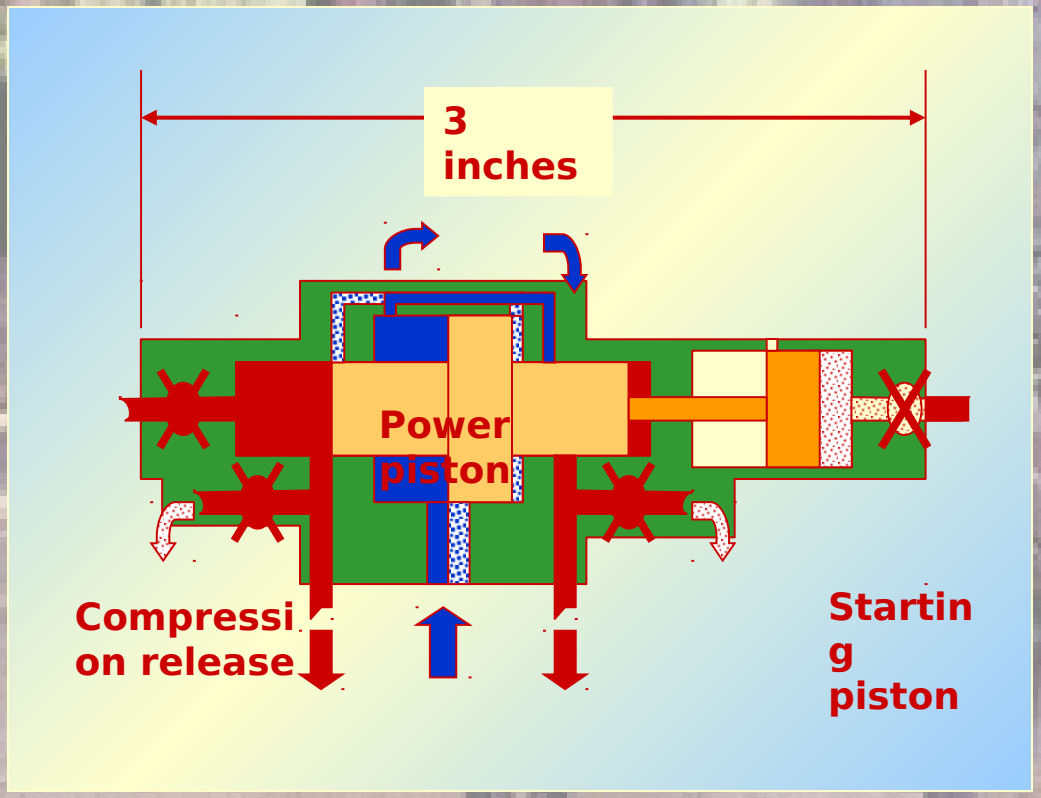
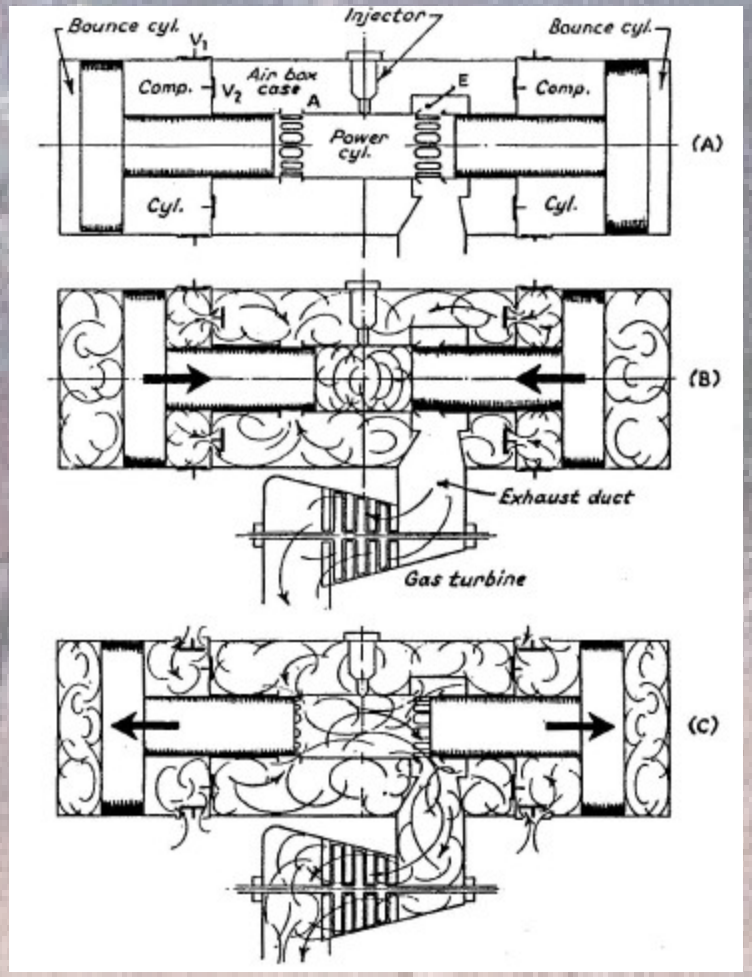
Quoin Free Piston Compressor-Ti-BOT





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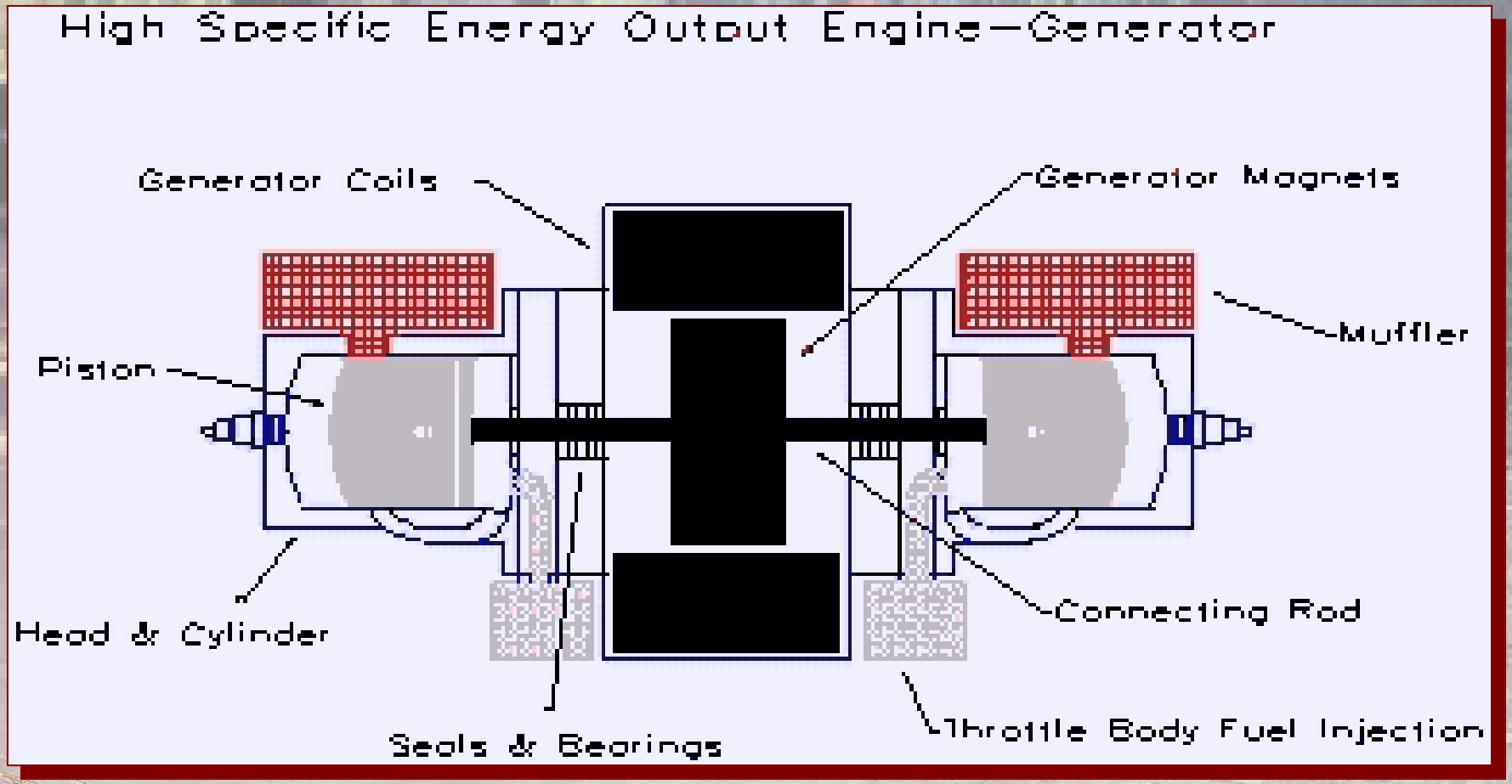
Free-Piston-Powered Alternator



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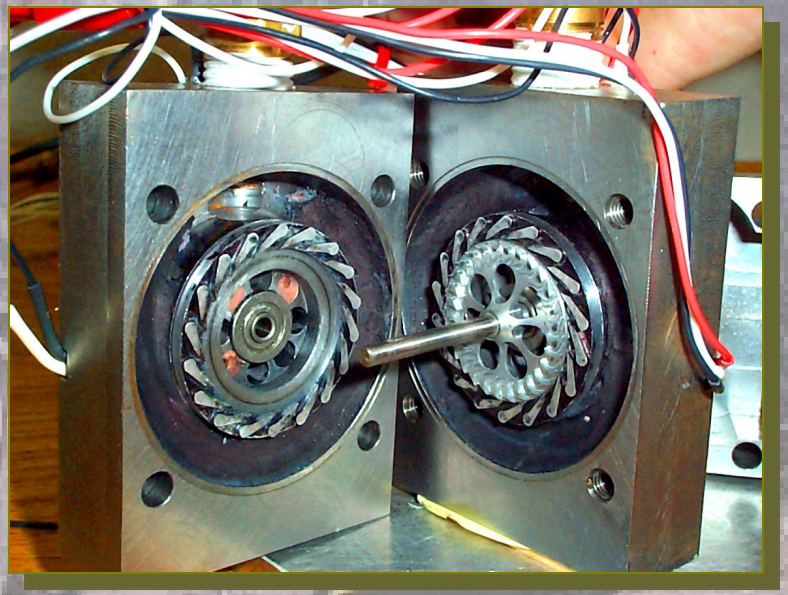
Robo Guy



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Turbine Design

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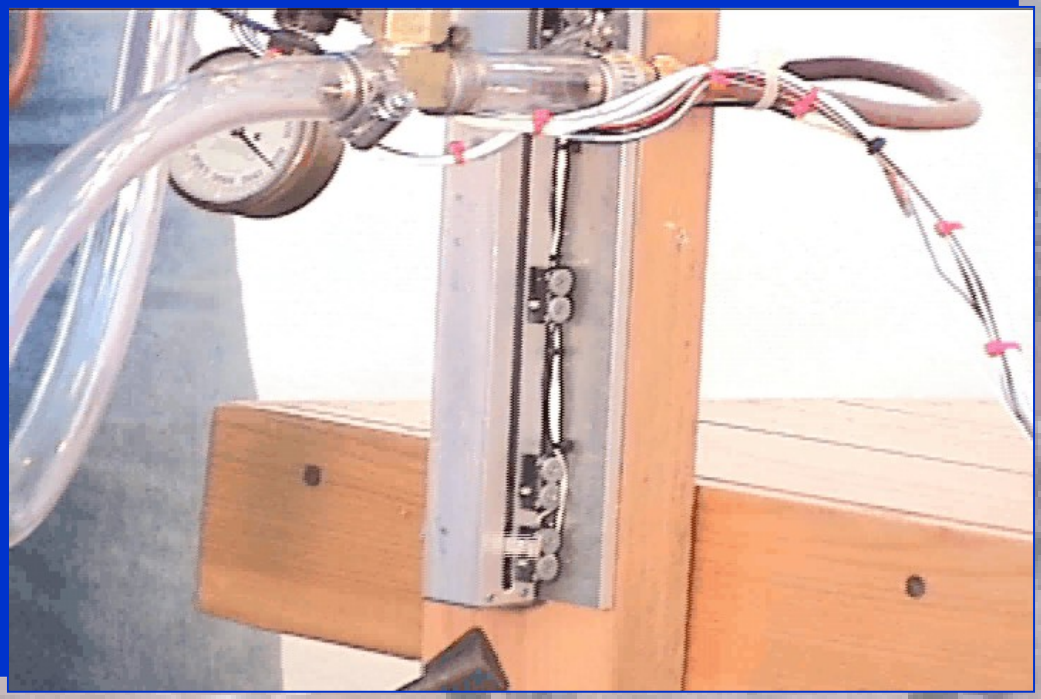
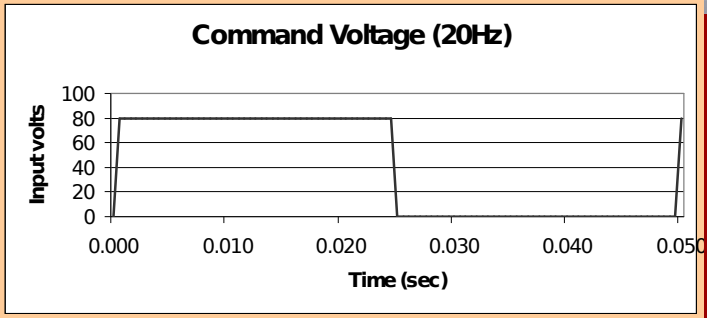
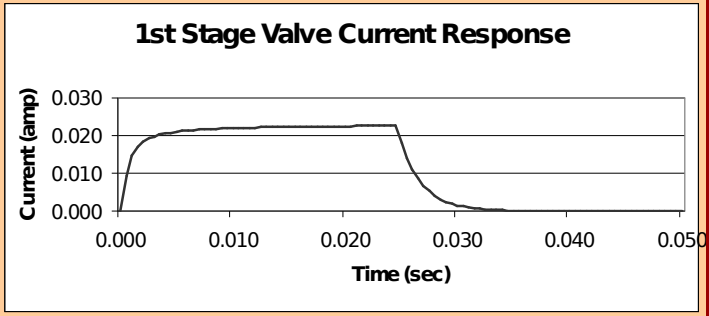
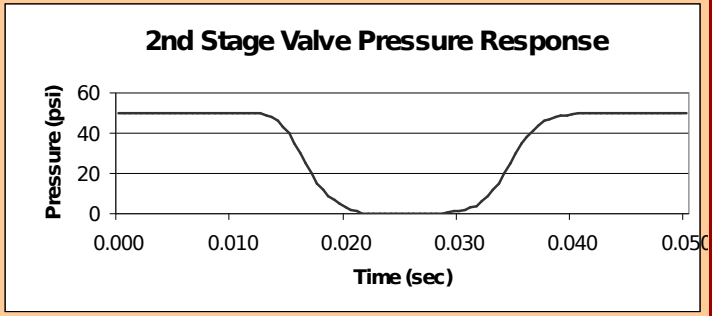
Prototype Test Data









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25 & 50-lb Tests

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Conclusions

- Ti-Bot is best for exo-skeleton
  - High force of hydraulic
  - Stiffness of electro-mechanical
  - 1/4 the weight of electro-mechanical and 1/5 fuel flow of hydraulic.
  - Free Piston Engine is smallest size and most fuel efficient.